(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
22 November 2001 (22.11.2001)

PCT

(10) International Publication Number
WO 01/88583 A1

(51) International Patent Classification[7]: G02B 6/38, B23K 26/20

(21) International Application Number: PCT/IB01/00779

(22) International Filing Date: 9 May 2001 (09.05.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
00110361.3 13 May 2000 (13.05.2000) EP

(71) Applicant *(for all designated States except US)*: **TYCO ELECTRONICS AMP GMBH** [DE/DE]; Ampèrestrasse 12-14, 64625 Bensheim (DE).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **BAUER, Juergen** [DE/DE]; Unterer Graben 18, 85049 Ingolstadt (DE). **SCHERER, Clemens** [DE/DE]; Neubruchweg 14a, 82205 Gilching (DE).

(74) Agent: **HEINZ-SCHAEFER, Marion**; Tyco Electronics Logistics AG, Ampèrestrasse 3, CH-9323 Steinach/SG (CH).

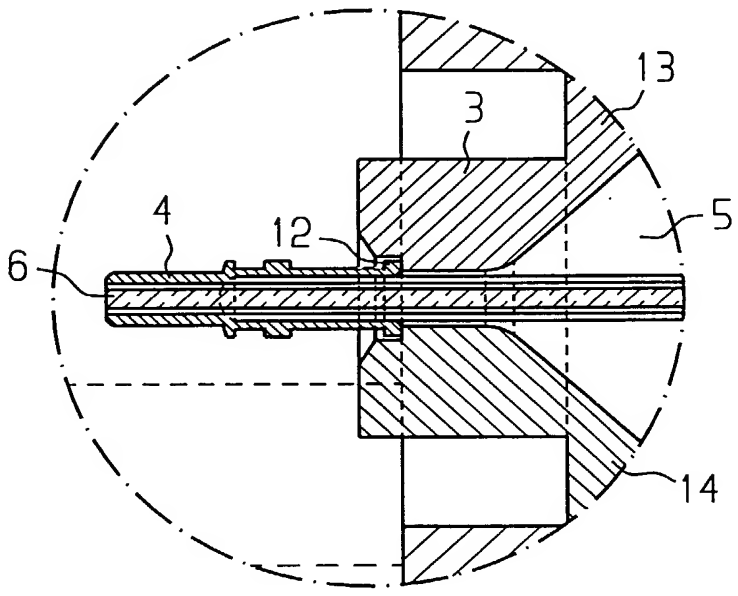
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: LOCATING APPARATUS FOR LASER WELDING AN OPTICAL WAVEGUIDE TO A FERRULE OF SYNTHETIC MATERIAL



(57) Abstract: The invention relates to a locating apparatus for laser welding an optical waveguide to a ferrule of synthetic material. Provided on a base plate (1) is a laser optics module for forming and deflecting a laser beam. The laser light source may be connected to the laser optics module (7) by an optical waveguide. Furthermore, the locating apparatus has a holder (3) which holds a ferrule (4) in a defined position for welding. Secured to the base plate (1) in one embodiment, are a plurality of laser optics modules (7) which weld the optical waveguide (6) to the ferrule (4) at a plurality of points on the external diameter of the optical waveguide.

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LOCATING APPARATUS FOR LASER WELDING AN OPTICAL WAVEGUIDE TO A FERRULE OF SYNTHETIC MATERIAL

The present invention relates to a locating apparatus for assembling an optical waveguide to a ferrule.

In coupling of an optical waveguide to a transmitter or receiver or coupling from fibre to fibre, the end of the optical waveguide is pre-fitted with a ferrule (also called an insert). The ferrule may be inserted into an optical interconnection system for precise alignment to a mating ferrule.

One possibility for securing the ferrule to the optical waveguide consists of connecting the two parts by means of a laser welding process. A process of this kind is shown for example in the periodical "Laserpraxis", June 1999, pages 16 ff. In this process, an important aspect is that the parts to be welded are positioned exactly.

However, there is no known apparatus by means of which the process can be applied to securing optical waveguides and ferrules. An object of the invention is therefore to propose such apparatus. In particular, the apparatus should be of simple construction and easy to use.

This object and other objects are achieved by providing a locating apparatus for laser welding an optical waveguide to a ferrule of synthetic material. The apparatus has a base plate, a holder secured to the base plate to receive the ferrule of synthetic material, a welding section of the received ferrule being accessible to a laser beam, and at least one laser optics module for forming a laser beam which is also secured to the base plate, the laser beam being focussed by the laser optics module onto the welding section of the received ferrule.

An advantage of the present invention resides in the fact that the locating apparatus described is a very compact and low-cost module, which can be used in various environments. Thus, it is suitable for manual location, for

example for production in small numbers, or in specimen production. However, the same module can also be used in a fully automated system, for example in higher production volumes. Arranging a plurality of modules next to one another is also conceivable. In a favourable embodiment, the locating apparatus has a plurality of laser optics modules, wherein the welding can be performed from different sides at the same time. This means that central alignment of the optical waveguide is ensured, since the thermal expansion from welding occurs on a number of sides. The holder can be constructed simply by comprising two halves, one or both halves being movable. In a closed position, the ferrule can be held securely between the two halves if the halves are shaped appropriately. After welding and opening of the halves, the complete pre-fitted optical waveguide can be removed.

A favourable embodiment of the invention is also provided if the laser light is supplied to the laser optics module or modules by way of an optical waveguide. Thus, the laser does not have to be arranged in the direct vicinity of the locating apparatus. Similarly, monitoring devices, for example to watch over the position of the ferrule and the optical waveguide, can be provided and arranged such that it is simple to remove them or assemble them again.

In a favourable embodiment for use in a fully automated system, the ferrules are supplied to the locating apparatus by way of an endless belt, in which case the endless belt may be formed for example by injection moulding a plurality of ferrules to one another. The halves of the holder of the locating apparatus may in this case be constructed such that they can be used to detach the ferrules from the endless belt so that the ferrules are located in the correct position for welding. The halves of the holder must of course then also be actuated automatically. This is done, for example, by a conventional crimping press. The locating apparatus is then constructed such that its external

geometric dimensions are adapted to the available dimensions of the crimping press. In order minimise the size of the locating apparatus the laser optics module is provided with a corner reflector, so that the laser optics module can be mounted perpendicularly upright on the base plate. The longitudinal axis of the laser optics module and the longitudinal axis of a received ferrule therefore extend parallel to one another.

The invention will be explained in more detail below by way of an example embodiment and with reference to the drawings, in which:

Figure 1 shows a locating apparatus according to the invention, in a cross-section;

Figure 2 shows a detail of the locating apparatus from Figure 1;

Figure 3 shows the locating apparatus from Figure 1 in a three-dimensional illustration;

Figure 4 shows a second example embodiment of a locating apparatus according to the invention, with an endless belt; and

Figure 5 shows the locating apparatus from Figure 4 in cross-section.

In Figure 1, a base plate 1 is mounted on a stand 2, so that the base plate 1 is perpendicularly upright, for example on a workbench. Connected to the base plate 1 is a holder 3, which receives a ferrule 4. In the example embodiment of Figure 1, the holder is simply constructed so that it has a cutout into which the ferrule 4 can be introduced. The rear end of the ferrule 4 is introduced into the cutout while a welding section of the ferrule remains freely accessible. A funnel 5 is formed on a side of the holder 3 opposite the ferrule introduction side. An optical waveguide is supplied from this side. As it is supplied, it is deflected by the funnel 5 onto a central cutout in the ferrule 4. In the embodiment shown in Figure 1, the holder 3 is a separate component which is inserted into the base

plate 1. It comprises two movable halves 13 and 14 from which the ferrule connected to the optical waveguide can be removed after opening.

On the side of the base plate 1 from which the ferrule 4 is supplied there is mounted a laser optics module 7. The laser optics module 7 has lenses 8, for the formation of a laser beam, and a corner reflector 9, for deflecting the laser beam. In the embodiment shown, the locating apparatus forms a module in which all the supply devices and any monitoring devices required are uncoupled from the module. No laser light source is provided in the locating apparatus, but rather the laser light is supplied to the laser optics module 7 by way of an optical waveguide through a plug coupling 10. The plug coupling 10 can connect the optical waveguide to the module and detach it therefrom. Once the beam has passed through the optical waveguide of the laser light supply, there is a spatial distribution of energy, which is particularly well suited to synthetic material laser welding.

The laser beam is deflected by the corner reflector 9 such that it is substantially perpendicularly incident on the ferrule 4. In order to achieve a compact construction, the longitudinal axes of the ferrule 4 and the laser optics module 7 are parallel. Readily exchangeable protective glasses 11 are located between the corner reflector 9 and the ferrule 4 in order to prevent the interior of the laser optics module 7 from becoming soiled. The laser optics module 7 may also be pressurized and/or the region in which the ferrule 4 is welded may be subjected to a vacuum in order to keep dust and deposits away from the optics of the laser optics module 7. In the case of pressure in the laser optics module 7, a protective gas can also be used.

Figure 2 shows an enlarged detail of the location apparatus from Figure 1. The ferrule 4 is supplied to the holder 3. This can be done manually or automatically. In all cases, it must be ensured that before welding, a ferrule is

located precisely in the module in the welding position, "head first". A sensor used for monitoring may be connected to a control so that welding can only be started if the ferrule 4 is in the correct position. A securing mechanism of this kind can also be used to introduce the optical waveguide. It is in fact important that the end face of the optical waveguide 6 and the plane of the end face of the ferrule 4 are identical or are located at a defined spacing from one another. In the example embodiment of Figures 1 and 2, the locating apparatus is however provided for manual location without monitoring devices. Even without additional monitoring devices, it is possible to ensure that the ferrule 4 is in the correct position for welding. For example, an integral peripheral collar 12 may be formed on the ferrule 4. The ferrule 4 is urged into the cutout in the holder 3 until the peripheral collar 12 abuts the holder 3. The holder 3 is preferably secured to the base plate 1 such that it is readily exchangeable. In this way, the locating apparatus can be used for different ferrules needing holders matched to correspond to the shape of each ferrule.

The locating procedure is carried out as follows. First the ferrule 4 is pushed into the cutout in the holder 3. This may be done manually, or by way of a gripper, which pushes the ferrule 4 in. In the second step, the optical waveguide 6 is pushed in from the other side of the base plate 1 until the end face of the optical waveguide is flush with the end face of the ferrule 4. The section of the optical waveguide 6, which is to be received in the ferrule 4, must be pre stripped. Once the optical waveguide has been pushed into the ferrule 4, welding can start. The laser beam penetrates the material of the ferrule 4, which is largely transparent to the wavelength of the laser light. In this region the optical waveguide 6 still comprises a core and an internal protective covering. The material of the internal protective covering is selected such that it absorbs laser light. Under the action of the laser light, the internal

protective covering melts at this point and welds the optical waveguide 6 to the ferrule 4.

In order to guarantee that the optical waveguide 6 is securely held in the ferrule 4 and to ensure that the optical waveguide 6 is in a central position in the ferrule, a plurality of laser optics modules 7 are provided on the base plate 1, as can be seen in Figure 3. One of the laser optics modules 7 is shown and the position of the others can be discerned from the cutouts provided therefor. The laser optics modules 7 are arranged concentrically around the received ferrule 4, so that the optical waveguide 6 is welded to the ferrule 4 at three points on its periphery, wherein the weld seams lie at an angular spacing of 120° from one another.

In a further embodiment of the invention in accordance with Figure 4, the locating apparatus is constructed such that it can be used in a fully automatic cable pre-fitting machine. For this purpose, two further objects have to be achieved. First, opening and closing of a holder 23 must function automatically, and second, supply of the ferrules must be automated. In this embodiment, the locating apparatus is preferably constructed so compactly that the holder 23 can be actuated by a crimping press. However, it is also conceivable to use a separate pneumatic cylinder to actuate the holder. The holder 23 comprises an upper and a lower die which are formed by halves 33 and 34 which are movable in opposite directions.

Ferrules are conventionally supplied as bulk goods, which need to be automatically positioned for welding. Component-specific vibration conveyors or drums and component-specific vibration rails can be provided. The investment costs for these are, however, considerable. It is therefore advantageous to have the ferrules made on an endless belt 36 or connected to such a carrier component. The locating apparatus of this embodiment is modified so that the ferrules 4 are separated from the endless belt 36,

which is guided by guide rails 35, and then held by the halves of the special holder 23. The halves of the upper and lower dies are thus shaped such that that on closing they detach a ferrule 24 from the belt, hold it until the welding process is completed and then open again and release the complete pre-fitted optical waveguide. A conveyor tool for further conveying of the belt can be coupled to the closing and opening process of the holder.

With reference to Figure 5, which shows a cross-section of the locating apparatus from Figure 4, the compact construction of the locating apparatus can again be seen. Moreover, detail of a welding chamber 37 is provided. This closed space of the welding chamber 37 is put under vacuum pressure so that the laser optics modules 7 are protected from the ingress of dirt and dust particles.

The locating apparatus described is mainly provided for processing synthetic material optical waveguides. They are also suitable for glass optical waveguides, since the welding is not performed on the core of the optical waveguide but instead on the internal protective covering. It is therefore sufficient if the internal protective covering is made of a weldable material.

CLAIMS

1. A locating apparatus for laser welding an optical waveguide to a ferrule of synthetic material comprising:

a base plate (1);

a holder (3, 23) connected to the base plate (1) to receive the ferrule (4), a welding section of the ferrule (4) being accessible to a laser beam; and,

at least one laser optics module (7) which is also secured to the base plate (1) for forming a laser beam, the laser beam being focussed by the laser optics module (7) onto the welding section of the received ferrule (4).

2. The locating apparatus according to Claim 1, wherein the at least one laser optics module (7) has an apparatus (9) for deflecting the laser beam.

3. The locating apparatus according to Claim 1, wherein the holder (3) has a fixed and a movable section or two movable sections (13,14; 33,34), for receiving the ferrule (4) between the two sections (13,14; 33,34) and for holding the ferrule when the two sections (13,14; 33,34) are in a closed position.

4. The locating apparatus according to Claim 1, wherein laser light is supplied to the at least one laser optics module (7) by way of an optical waveguide.

5. The locating apparatus according to Claim 1, wherein a plurality of laser optics modules (7) are arranged on the base plate (1), the ferrule (4) being positioned centrally between the modules (7) and the laser beams of all the laser optics modules (7) being directed at the welding section of the ferrule (4).

6. The locating apparatus according to Claim 1, further comprising a protective glass (11) located at the beam output from the at least one laser optics module (7), to prevent the interior of the laser optics module (7) from becoming soiled.

7. The locating apparatus according to Claim 1, wherein a pressure is generated in the interior of the at least one laser optics module (7).

8. The locating apparatus according to Claim 1, further comprising a welding chamber formed to receive the welding section of the ferrule (4) during a welding process.

9. The locating apparatus according to Claim 1, further comprising monitoring devices to watch over the position of the ferrule (4) and the optical waveguide (6).

10. The locating apparatus according to Claim 1, wherein a longitudinal axis of the ferrule (4) and a longitudinal axis of the at least one laser optics module (7) extend parallel to each other.

11. The locating apparatus according to Claim 1, wherein the ferrule (4) is supplied automatically.

12. The locating apparatus according to Claim 1, further comprising a separating apparatus having a fixed and a movable part of the holder (23) or two movable parts of the holder (23), whereby the ferrule (4) may be detached from a continuous belt (36) of mutually connected ferrules (4).

FIG 1

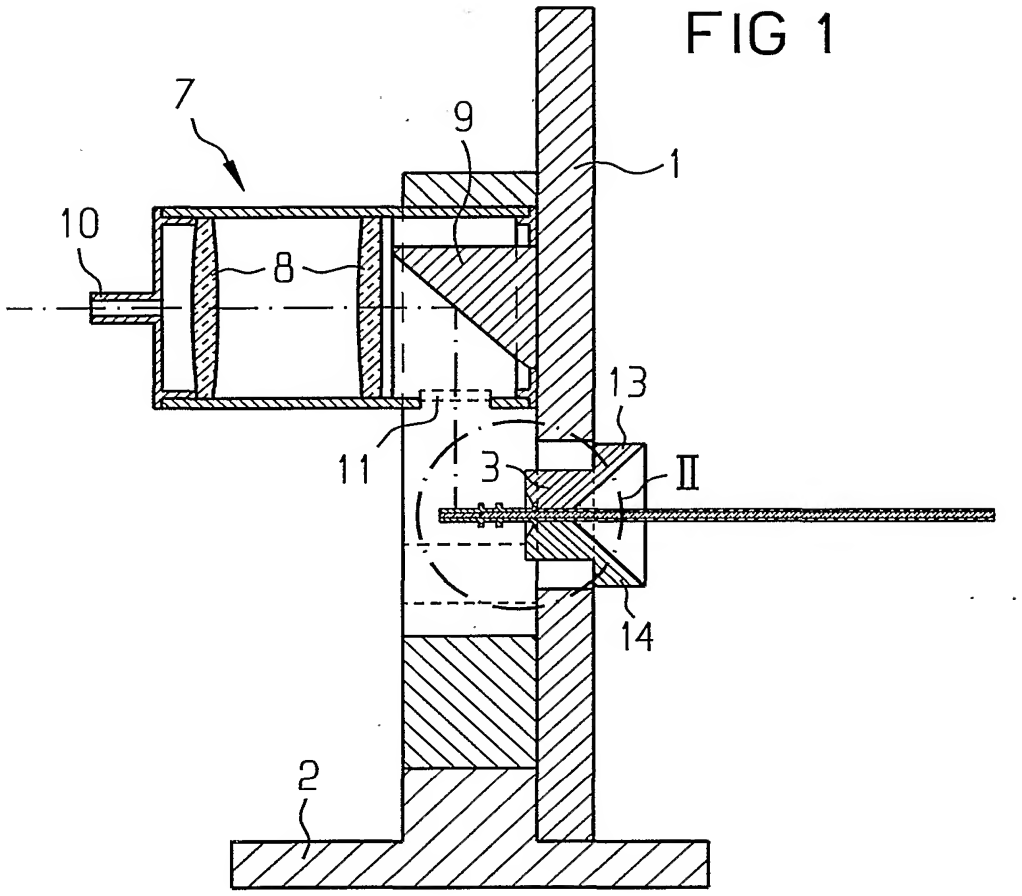


FIG 2

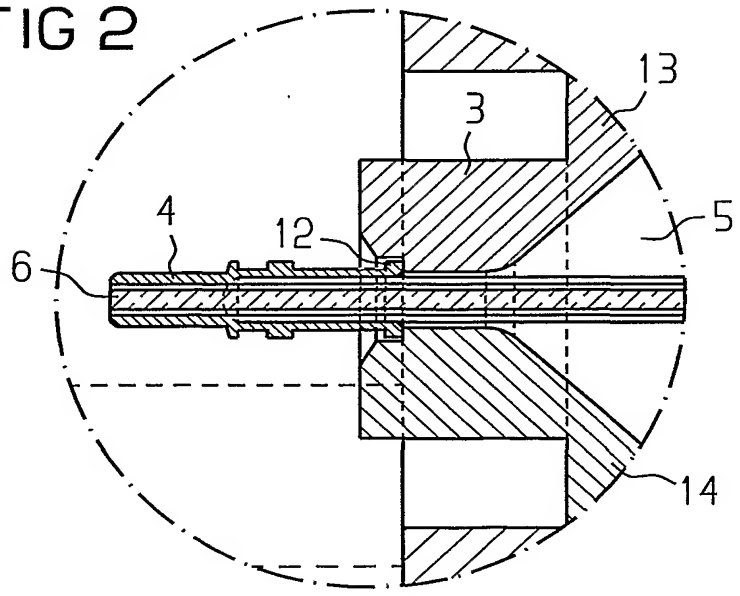


FIG 3

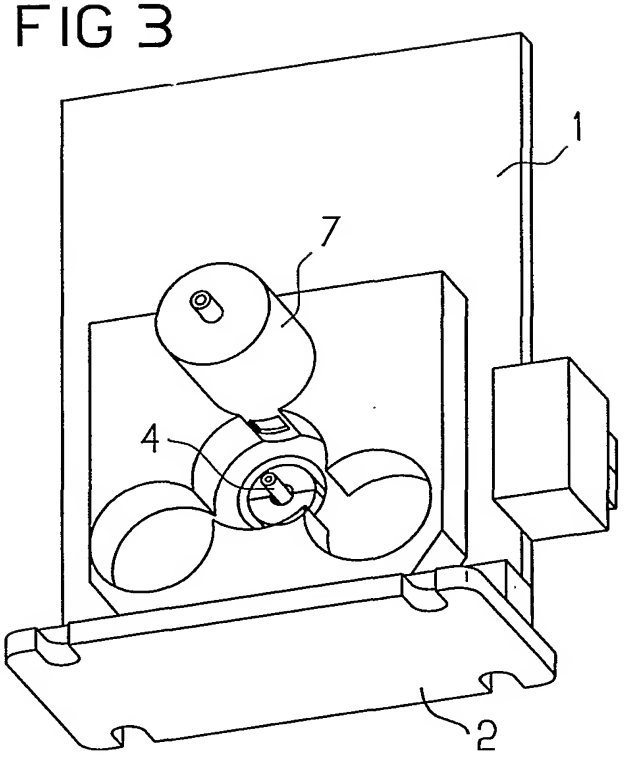


FIG 4

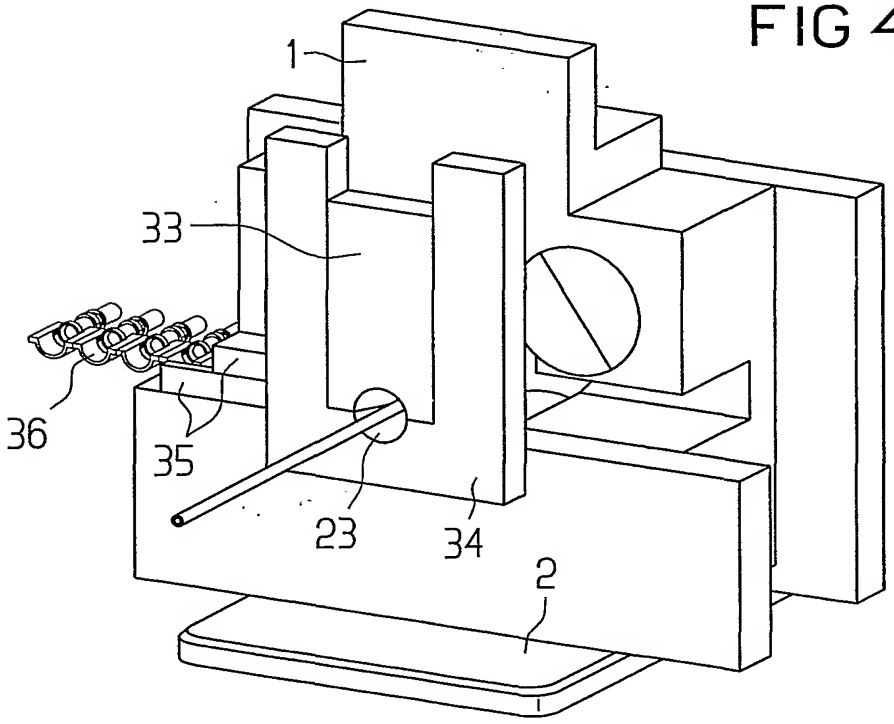
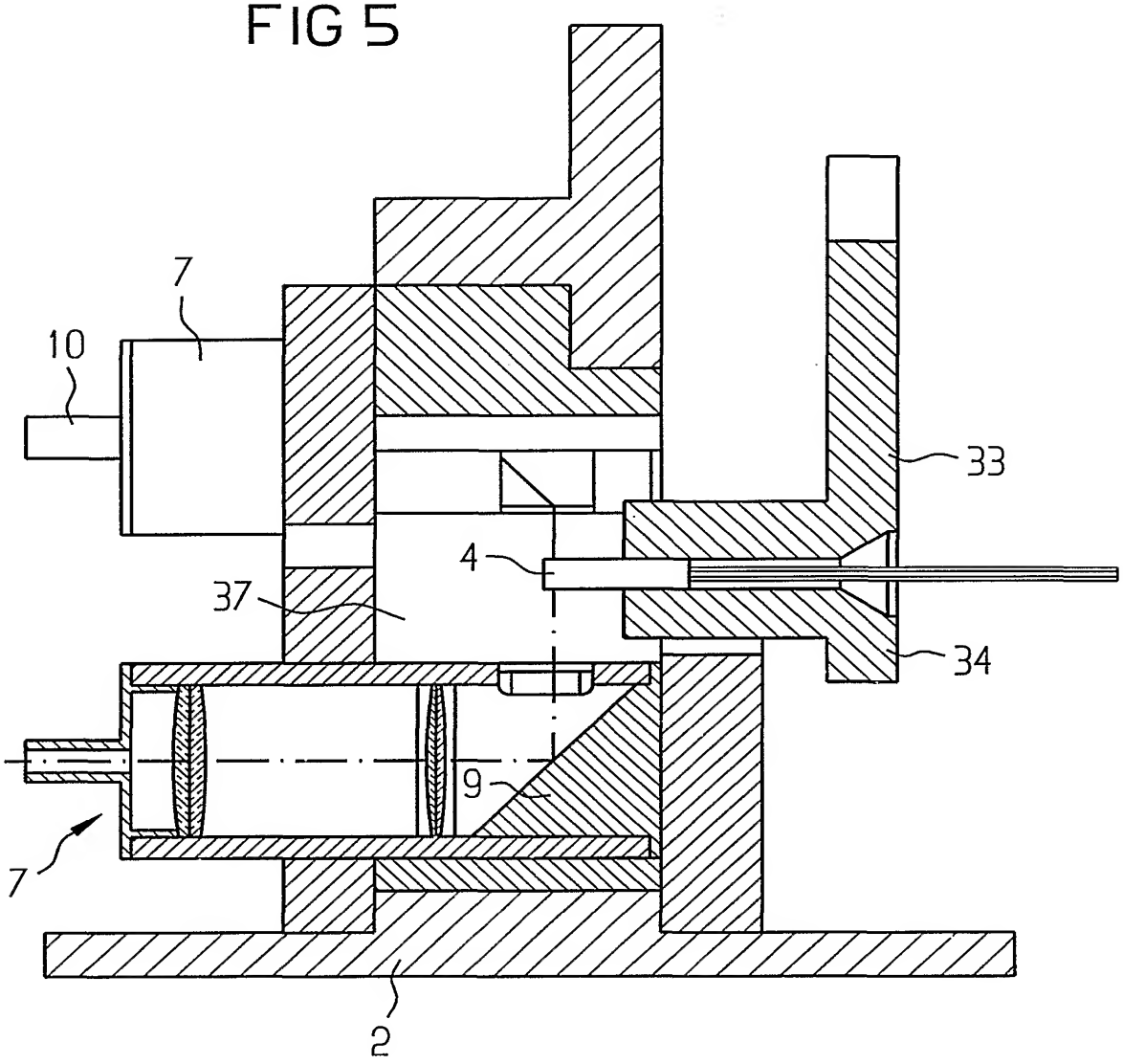


FIG 5



INTERNATIONAL SEARCH REPORT

Ii itional Application No
PCT/IB 01/00779

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G02B6/38 B23K26/20

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B23K G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 587 895 A (FUJITSU) 23 March 1994 (1994-03-23) column 10 -column 11; figures 6-10	1
A	PATENT ABSTRACTS OF JAPAN vol. 2000, no. 04, 31 August 2000 (2000-08-31) & JP 2000 019363 A (KOREA ELECTRONICS TELECOMMUN), 21 January 2000 (2000-01-21) abstract & US 6 087 621 A (KOREA ELECTRONICS TELECOMMUN.) 11 July 2000 (2000-07-11) column 3 -column 5; figures 1-4	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
3 August 2001	09/08/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Malic, K

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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